NICKEL-HYDROGEN SEPARATOR DEVELOPMENT

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SUMMARY

The separator technology is a critical element in the Nickel-Hydrogen ($Ni-H_2$) systems. Previous research and development work carried out at NASA Lewis Research Center has determined that separators made from zirconium oxide (ZrO_2) and potassium titanate (PKT) fibers will function satisfactorily in $Ni-H_2$ cells without exhibiting the problems associated with the asbestos separators. These separators and their characteristics have been previously discussed. A program has been established to transfer the separator technology into a commercial production line. A detailed plan of this program will be presented and the preliminary results will be discussed.

INTRODUCTION

A separator development program have been in effect at NASA Lewis Research Center for a number of years. Lately this development program have been focused on the development of new non-asbestos separators for $Ni-H_2$ cells and batteries. These separators were to have equal performance to asbestos while eliminating the present separator problems associated with the asbestos availability and environment. A new set of separators made of potassium titanate (PKT) and zirconium oxide (ZrO_2) fibers and a binder have been developed and tested as previously reported (ref. 1). To date the new separator material have been manufactured manually by the use of handsheet molds capable of producing 8 in. square sheets at a very low production rate. In order to demonstrate the feasibility of using this new separator material in a variety of different applications it would be necessary to produce longer sheets at higher production rates. In an effort to bridge the gap between the handsheet operation and the commercial processes a research program has been put into effect with the Paper Science and Engineering Department of the Miami University of Ohio. The objective of this communication is to present the research program plan and its status and discuss the preliminary results in relation to their effect on nickel-hydrogen cells and batteries.

SEPARATOR TECHNOLOGY

The separator development program will consist of three phases with the objective of demonstrating the feasibility of manufacturing the new separator materials using a standard paper making techniques. The final result to be a separator which, by the nature of the process, will be more uniform and easily reproduced. These objectives will be accomplished in three different phases:

Phase I - Duplication of NASA Handsheet Procedures

The objective of this phase is to familiarize the Miami University staff with the working materials and their particular characteristics and behavior. NASA handsheet are to be duplicated so as to establish the procedure and the required properties of the final mat. The availability of new materials or modifications in those used by NASA and their effect will be studied and attempts made to produce these handsheets using standard paper forming operations.

Phase II - Determination of Conditions For Paper Machine Run

This phase is designed to identify the conditions and composition required to produce an acceptable handsheet employing a normal forming fabric with a handsheet mold and to identify the starting conditions to be used in the initial paper machine experimental runs. Of interest in this phase are the forming fabrics, fine solids retention, sheet dewatering, and distribution of materials in the handsheets. Also, the effect of fillers and binders on the characteristics of the separator with special interest on increasing the bubble pressure.

Phase III - Production of Separator Paper on the Pilot Machine

The success of the paper machine runs will depend largely on the Miami University skills and expertise coupled with the knowledge gained in phases I and II of the program. The conditions, the composition and order of addition of the components that produce the best papers in phases I and II will serve as the starting points for the paper machine experiments. Subsequent paper machine trials will be designed based on the results of the initial run plus any additional information gained from "bench-scale" experiments that will be run throughout this phase. The production of an acceptable separator that could be reproduced and meets the desired performance characteristics is the ultimate goal of phase III and the program.

DISCUSSION

The Lewis separators were made on a Williams sheet mold and were filtered onto a closely knitted filter sheet. This was only an interim solution to the retention problems posed by the small PKT fiber size. It was later discovered that the distribution of material throughout the sheet was not uniform. The use of the filter sheet also made it very difficult to adapt to an effective manufacturing production processes. An attempt was made by a commercial manufacturer to produce the separator handsheets on sheet molds employing normal open-mesh fabrics but resulted in poorly formed sheets that did not have desirable properties. Pinholes occurred frequently and it was often difficult to remove the sheets from the sheet mold. These problems are probably related to poor retention of fine solids in the sheet (pinholes) as well as inadequate dewatering (low web strength). An SEM picture which represents this phenomena is shown in figure 1.

To solve the above problems, efforts will be made to increase the retention of PKT and dewatering rate during handsheet formation. The improvement

of sheet formation (distribution of mass throughout the sheet) will also be investigated, which will enhance wet web formation and improve most other properties as well.

Since the initial Lewis separators can not be reproduced under the paper machine environment due to changes in the manufacturing procedure, an attempt is being made to reproduce the separator properties when using the new techniques. A new development on ZrO_2 fibers has occurred since the Lewis separators were made. There is a new fiber now available ZrO_2(TCW) which is more flexible and has a longer length than those available to us before. This increases the strength of the mat and makes it easier to form the sheets on a standard forming fabric. Preliminary sheets were made which formed very nicely on the standard forming sheets. As shown in Table I these results are very encouraging, reproducing all the desired properties except for a lower bubble pressure. In the separators with the lower ZrO_2 composition, problems started to develop where it became difficult to remove the sheet from the forming fabric. When the standard ZrO_2 bulk fibers where used similar problems were encountered. Experiments are now being designed with the purpose of improving the bubble pressure by means of filler addition, binder composition and applied pressure, among others. The impact of this new fiber on separator characteristics and cost needs to be evaluated. Since the cost of the new fiber is much more than the original bulk fiber an attempt will be made to find the best composition mixture using both fibers.

In addition to these experiments, the effect of the binder on material strength (wet web) will also be investigated. Although some binder tests were performed at Lewis these experiments become much more important at this state of development. The amount of binder on the Lewis separators could not be determined and the actual retention seemed to have been quite low judging from SEM pictures taken. The increased binder retention as seen in the improved sheet flexibility and strength of the Miami University separators could significantly affect the separator characteristics for the better. These could also be affected by the binder formulation. Previous testing done has shown a greater strength can be achieved with a polyacrylic acid binder but water retention will also be increased possibly affecting the dewatering process in an adverse manner. These separators will be subjected to the same screening tests as in reference 1.

As was previously shown (ref. 2) the separator effects the voltage characteristics in the cell. We also know that it also effects the volume tolerance of the cells (ref. 3) thereby possibly controlling the cycle life. The pore size distribution of these separators have been and will continue to be closely monitored to ensure effective pore size distribution. The separator is also required to effectively control the rate and location of the oxygen recombination as have been designed into the Lewis advanced IPV and Bipolar design configurations (ref. 4). At the end of this program this technology will be ready to be translated to other paper machines for large scale production of these separators. They will be verified by short term characterization and long term cycling in nickel-hydrogen cell hardware with subsequent post test analysis.

CONCLUDING REMARKS

The impact of these separators an nickelhydrogen systems is expected to result in equal or better performance than asbestos, increased cycle life and improved heat and electrolyte management in coordination with advanced designs. There are currently no separators that will accomplish these goals since the current supply of good asbestos fibers is limited and is rapidly being consumed. Preliminary results are encouraging. These new separators are expected to be ready and available to the battery community by 1987.

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TABLE I. - SEPARATOR PROPERTIES

Composition	Resistivity, ohm-cm	Electrolyte retention, percent	Porosity, percent	Bubble[a] pressure, psi
80% PKT 20% ZrO_2 10% EBL	2	171	69	>30
80% PKT 20% ZrO_2(TOW) 10% EBL	2	147	80	9
100% PKT 5% ZrO_2(TOW) 10% EBL	2	172	86	12

[a]Best sample

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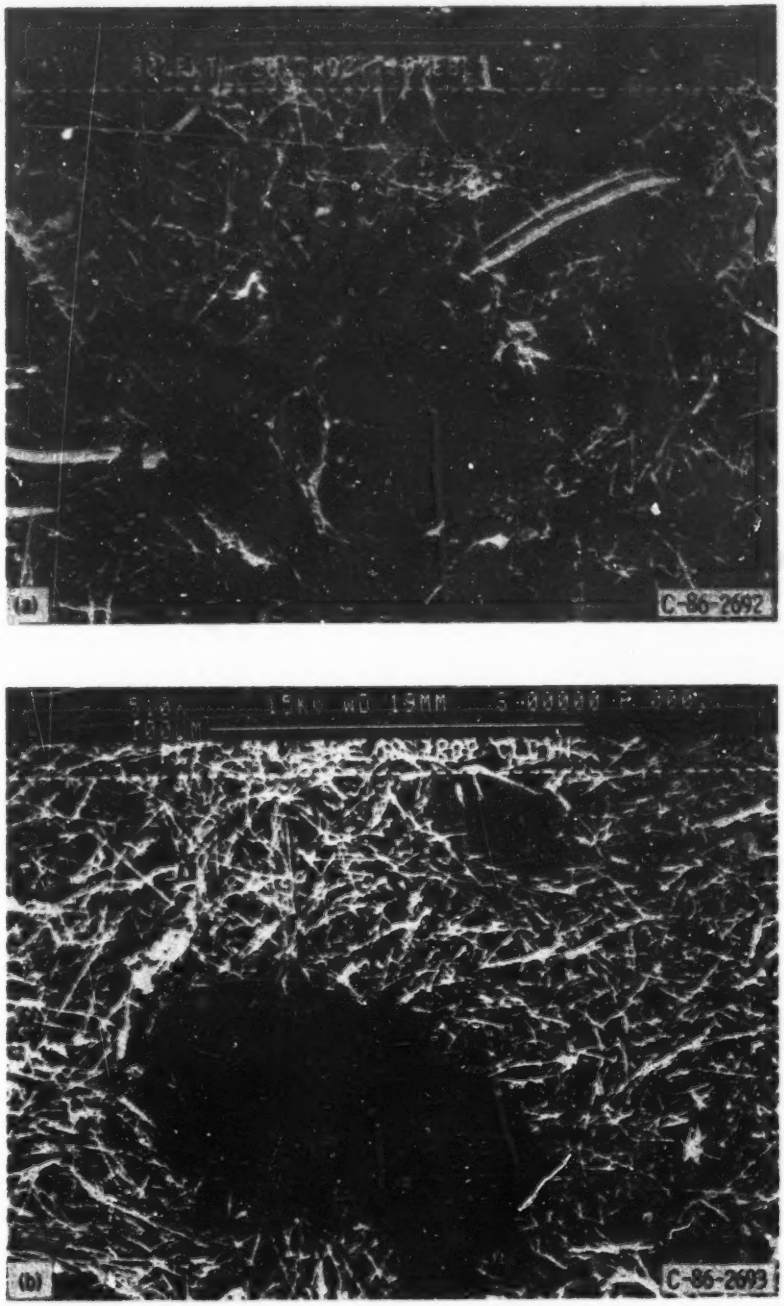

Figure 1. - Separator deffects.

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